CARRIER TELEPHONES

By JACK A. TAYLOR

The most important single element in making modern long distance telephony possible, at a reasonable price, is the development of the carrier system. This system is distinguished by the fact that one pair of wires can carry up to 240 individual messages at one time without interference between the different conversations.

The principle of the system is very simple fundamentally. The idea is to take several conversations, change each of them to a different high frequency, send them all over the same wire, separate them according to frequency at the other end, then change them back to voice frequency, and send them to the individual subscriber at the other end.

One of the easiest ways of understanding it is through an analogy with a system of lights. Imagine seven bulbs each a different spectral color. Now if these bulbs were to go on and off to give the dots and dashes of the Morse code we could transmit a message by each of them. To a person at a distance however the different lights would not be distinguishable, but would seem like a white light. But if we give the man at the receiving end seven pairs of colored glasses, he can read any of the messages he wants by merely putting on the proper pair of glasses which would cut out all the light except from the bulb of the same color as his glasses, and he could read the message without interference from any other message.

There are six main elements in a carrier system. They are a microphone to pick up the voice, a generator to give the high frequency, a modulator to combine the two frequencies, a line to transmit the combination, a demodulator to get the voice frequency back again and an earphone to change the electrical energy into speech.

The telephone microphone has been known ever since Bell made the original, and no description of it is necessary.

The generator is merely a vacuum tube oscillator such as can be found in any modern home radio. This is also a common device not needing any further description.

The modulator is a device for varying the amplitude of a high frequency wave by a low frequency. It is usually a triode tube with the voice frequency applied to the plate and the high frequency applied to the grid, although some other systems are in use.

The modern telephone line is still essentially two wires strung between the two people talking but is a great improvement over an ordinary wire. An ordinary pair of wires loses most of the input power in a matter of a few miles and therefore must be amplified at intervals. It has been estimated that if a regular voice current was to start at New York and go to San Francisco with only one amplifier at Saint Louis, the amplifier at Saint Louis would have to put out more power than the sun if the New Yorker were to be heard in San Franciso. The telephone line also attenuates the different frequencies unequally so it is necessary to correct for this condition too. This is done by inserting loading coils every mile or so. There are other refinements but they need not be gone into here.

To separate the different frequencies at the receiving end, an electric wave filter is used. This was the last device developed in the carrier system and the system was put into use soon after it was invented. It consists of a network of pure inductances and capacitances which let the desired frequencies through and stop all of the others.

The demodulator at the other end takes the superimposed voice frequency and rejects the carrier frequency thus giving the original audio frequency back at the other end of the line. The usual demodulator is the same as the one in any household radio which separates the voice from the radio frequency. In fact carrier telephones and radio are almost the same except that the radio radiates its power into space, and the carrier is sent over wires.

The final piece of apparatus is the earphone on the telephone set at the receiving end which is familiar to everyone and needs no explanation.

The carrier system is used only on long lines where the cost of the extra wire needed is greater than the cost of installing the extra equipment needed for the carrier. The C-carrier system will carry four messages at the same time at frequencies up to 30,000 cycles per second. The more recent type J system carries 12 messages at frequencies from 36,000 to 142,000 cycles per second. When they are both used on the same line 16 mesages can be transmitted simultaneously.

A different use of the carrier system is made by power and light companies. They already

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have wires available so they send all their communications over the power lines, and use simple filter device to keep the high voltage away from the telephone sets. Since the war, many hams have started experimenting with carrier system on power lines as they are not allowed to broadcast.

Recently there have been many advances in the carrier systems, and in the newest systems all that is left of the old systems is the subscribers' handset. The principles are still the same but the equipment has been vastly improved.

The carrier frequencies are now generated by an electromagnetic generator with a distorted output high in harmonics. Its advantages are that only one generator is needed and the carrier frequencies always have the same number of cycles between any two successive harmonics. Both modulation and demodulation are now done with copper oxide rectifiers connected in a bridge type circuit. The copper oxide rectifiers are superior to vacuum tubes in that they are more reliable and last practically forever.

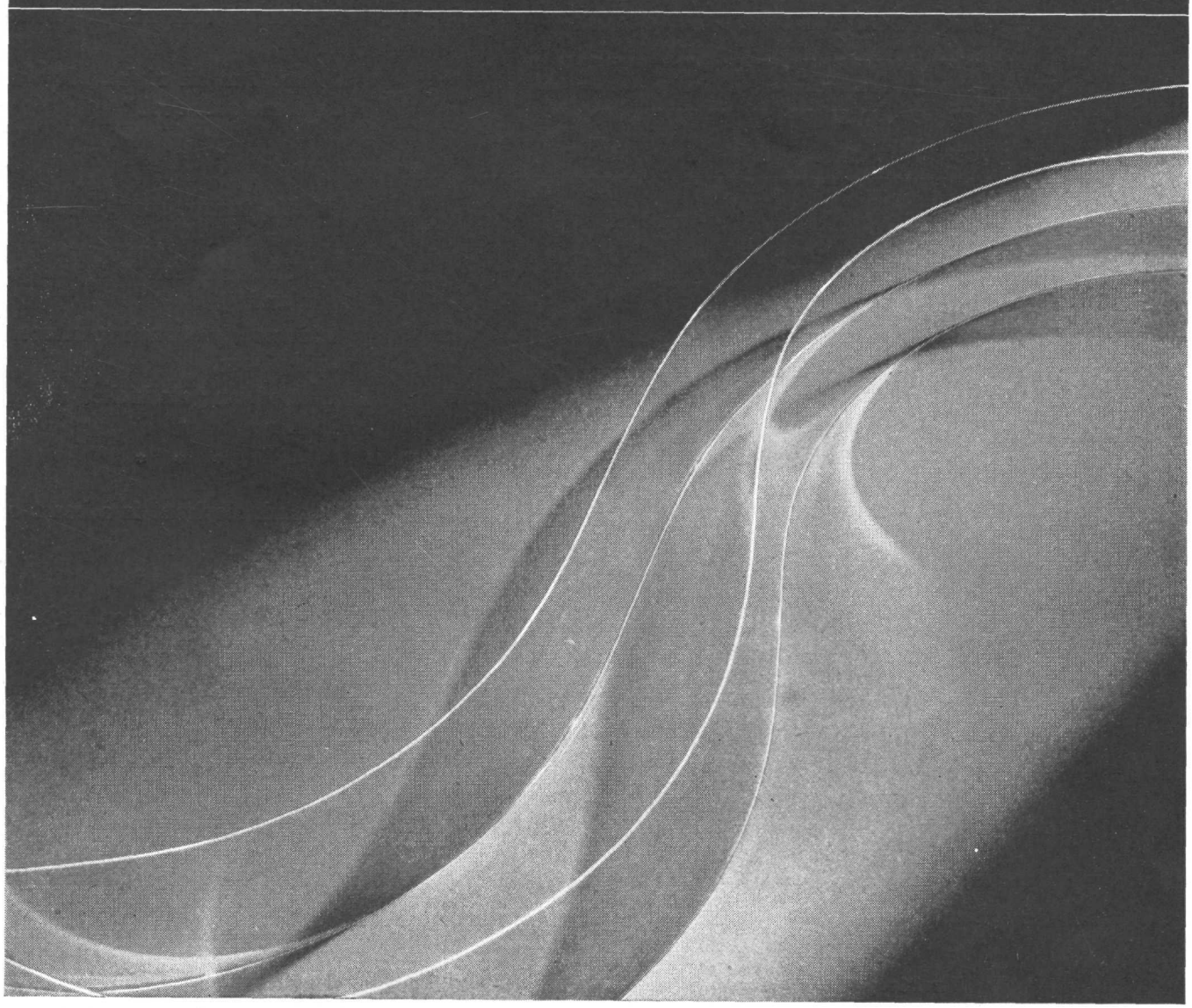
The new type of line consists of an inner conductor with a copper tube around it which acts as the other conductor. This is the co-axial cable which is so important to television and very high frequency work, such as radar. The amplifiers have been improved to give constant gain over the required range of frequencies.

Instead of the reactance filters used on ordinary systems, crystal filters are used in the new system. These consist of a small piece of quartz between two parallel metal plates. At the crystal filters mechanical resonance point it is a very good conductor of electricity but at any other frequency it is a poor conductor. When it is connected in parallel with a condenser it will pass a narrow range of frequencies very well but will give a very sharp cutoff and attenuate all other frequencies.

This system will carry 240 conversations simultaneously. It can also carry a television program with a frequency of 0 to 1,000,000 cycles. This system's main use at present is only for traffic between two very large cities such as New York and Philadelphia.

From the above description one can see that carrier telephones take their place with other inventions that engineering ingenuity has wrested from an indifferent and sometimes seemingly hostile nature.

Glass like ribbon candy...



"WHAT do you think of this?" said the research physicist, hauling out a long wide flexible ribbon of glass as thin as paper. He shook it and it bent and rattled like rain on a roof.

"What's it for?" said the fellow who writes these ads. "Well," said the physicist, "it may have a lot of uses. We haven't had time to explore them all yet. But one we've already found is in wartime radio equipment."

This interesting new type of glass is just one of the many contributions of glass research to the war. For the glass industry has thrown its entire accumulated experience, engineering and research facilities, into the job of putting glass on the fighting and industrial fronts where it can hurt our enemies most.

War and Corning research have put glass in a lot of strange places. For instance, there was a time when almost all piping in chemical plants was alloy of one kind or another. Now chemical people have discovered that glass piping is better for many purposes, and Corning has even developed a method for welding it into continuous lengths.

What about the business *you* choose to follow? Perhaps someday glass can replace metals, speed production, improve products for you. It has for others, and Corning knows how to apply glass to many different problems. Keep it in mind. Corning Glass Works, Corning, N. Y.

CORNING
means
Research in Glass